PB81-125007

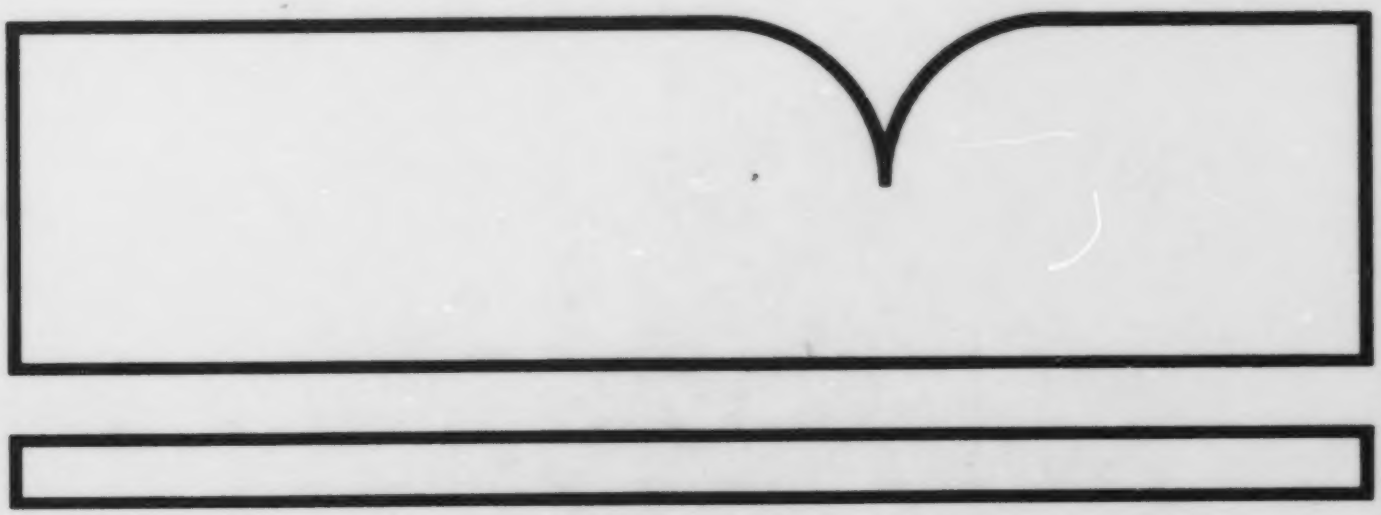
Gaseous and Particulate Ammonia and Nitric Acid Concentrations, Columbus, Ohio Area Summer 1980

University of South Florida, Tampa

Prepared for

Environmental Sciences Research Lab.
Research Triangle Park, NC

Dec 80



U.S. Department of Commerce
National Technical Information Service
NTIS.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/7-80-179		PB81 125007

4. TITLE AND SUBTITLE	5. REPORT DATE
GASEOUS AND PARTICULATE AMMONIA AND NITRIC ACID CONCENTRATIONS Columbus, Ohio Area--Summer 1980	December 1980 Issuing Date. 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Robert S. Braman and Timothy J. Shelley	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of South Florida Tampa, Florida	10. PROGRAM ELEMENT NO. CABN1D/11-0608 (FY-81) 11. CONTRACT/GRANT NO. Grant No. 806688
12. SPONSORING AGENCY NAME AND ADDRESS Environmental Sciences Research Laboratory-RTP,NC Office of Research and Development U.S. Environmental Protection Agency Research Triangle Park, North Carolina 27711	13. TYPE OF REPORT AND PERIOD COVERED Interim 14. SPONSORING AGENCY CODE EPA/600/09

15. SUPPLEMENTARY NOTES

16. ABSTRACT

Data is presented for gaseous ammonia and nitric acid and particulate ammonium ion and nitrate ion concentrations in air samples collected in support of the PEPE-NEROS study during the summer of 1980. Ground-level samples were collected near Croton, Ohio; aerial samples were also taken from an aircraft during several flights. Sampling and analyses were accomplished using the hollow and packed tube tungstic acid method that permits short sampling times of 10-30 minutes. Feasibility of sampling from aircraft was established. Quality control was maintained by measuring the preconcentration tube efficiency before and during field analyses.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air pollution * Ammonia * Nitric acid Gases Particles Chemical analysis	Columbus, Ohio area	13B 07B 07D

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

PB81-125007

EPA-600/7-80-179
December 1980

GASEOUS AND PARTICULATE AMMONIA AND NITRIC ACID CONCENTRATIONS
Columbus, Ohio Area--Summer 1980

by

Robert S. Braman and Timothy J. Shelley
University of South Florida
Tampa, Florida 33620

Grant No. R-806688010-01-2

Project Officer

William McClenny
Atmospheric Chemistry and Physics Division
Environmental Sciences Research Laboratory
Research Triangle Park, N.C. 27711

ENVIRONMENTAL SCIENCES RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

DISCLAIMER

This report has been reviewed by the Environmental Sciences Research Laboratory, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

Data is presented for gaseous ammonia and nitric acid and particulate ammonium ion and nitrate ion concentrations in air samples collected in support of the PEPE-NEROS study during the summer of 1980. Ground-level samples were collected near Croton, Ohio; aerial samples were also taken from an aircraft during several flights. Sampling and analyses were accomplished using the hollow and packed tube tungstic acid method that permits short sampling times of 10-30 minutes. Feasibility of sampling from aircraft was established. Quality control was maintained by measuring the preconcentration tube efficiency before and during field analyses.

CONTENTS

Abstract iii

Figures vi

Tables vii

1. Introduction 1

2. Conclusions and Recommendations 2

3. Analytical Procedures 3

4. Field Data 11

References 26

Preceding page blank

FIGURES

Page

Figure 1 Apparatus Arrangement for Preconcentration Tube Analysis. . . 4

Figure 2 Sampling Arrangement for Hollow Tubes and Packed Tubes. . . . 6

Figure 3 Typical Ambient Air Analysis for HNO_3 and NH_3 8

TABLES

Number		Page
1	Calibration Data: NH_3 and HNO_3 on Packed Tubes	13
2	Calibration Data: NH_3 and HNO_3 on Hollow Tubes	14
3	Croton, Ohio Samples: August 6, 1980	15
4	Croton, Ohio Samples: August 8, 1980	16
5	Aircraft Samples, Chem 1: August 8, 1980	17
6	Croton, Ohio Samples: August 9, 1980	18
7	Aircraft Samples, Chem 1: August 9, 1980	19
8	Aircraft Samples, Chem 1: August 11, 1980.	20
9	Aircraft Samples, Chem 1: August 12, 1980.	21
10	Aircraft Samples, Chem 1: August 13, 1980.	22
11	Leakage Experiments: August 14, 1980	23
12	Quality Check: August 14, 1980	24
13	Aircraft Samples, Chem 1: August 15, 1980.	25

SECTION 1

INTRODUCTION

Gaseous ammonia and nitric acid and their particulate forms, nitrates and ammonium salts are important atmospheric components. Nitric acid and sulfuric acid aerosol contribute to the acidity of air and to acid rain while ammonia is a biogenically produced neutralizing component (1). It is important to measure these nitrogen containing compounds so that, when supplemented by other data, a better understanding of their atmospheric chemistry may be achieved.

To this end samples were taken and analyses made in support of the PEPE-NEROS project in the Ohio River Basin area during part of a two week period in the summer of 1980. Analyses were carried out using the tungstic acid preconcentration technique developed earlier in this grant program (2). Samples were taken on the ground at Croton, Ohio and from the Chem 1 aircraft of the PEPE-NEROS program. This work also had as an objective proving the feasibility of taking samples from an aircraft using the tungstic acid hollow and packed tube system.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

Air sampling from an aircraft for ammonia, nitric acid, nitrates and ammonium ion was successfully conducted. Blank sampling tubes transported in aircraft but not sampled even over periods up to 12-14 hours had only small amounts of ammonia present as a blank. Nitric acid blanks were not detectible.

Since the bulk of data reported here are to be used by others participating in the PEPE-NEROS project no conclusions on the atmospheric chemistry of ammonia and nitric acid are intended. Nevertheless, it appears that a large fraction of nitrate-nitrogen in samples taken in the aircraft flights is present as nitric acid.

Quality control of both the packed and hollow tubes was done by standardization before and after operations. Both types of sampling tubes retained their sampling efficiency over their period of use.

It is recommended that the technique be further compared to other methods for gaseous and particulate forms of nitric acid and ammonia.

SECTION 3

ANALYTICAL PROCEDURES

Sampling

Ground level samples were taken at a field van site near Croton, Ohio using a small diaphragm pump and a calibrated rotameter. Short term samples (10-30 min) were taken. The preconcentration tubes were then sealed with Parafilm and returned to the laboratory at the Ohio State University Airport where analyses were performed within 3-6 hours.

Air samples were taken on flights of the Chem 1 aircraft also using a rotameter and diaphragm pump. Parafilm sealed samples were returned for analysis within 6-12 hours depending upon the flight time and course. Blanked tubes, were carried on some flights and returned unused. These tubes were analyzed along with tubes sampled in flight and provided a range of blank values.

Background Description of the Tungstic Acid Method

Preconcentration of HNO_3 and NH_3 from air depends upon the amphoteric acid-base character of tungstic acid, H_2WO_4, prepared by vacuum deposition onto the walls of hollow preconcentration tubes. Tungstic acid reacts with gaseous ammonia according to the equation:

$$H_2WO_4 + NH_3 \rightarrow NH_4HWO_4$$

Upon heating to approximately 400°C the reaction is reversed releasing the preconcentrated ammonia which can then be detected in an apparatus of the type shown in Figure 1 using a commercial model Bendix NO_x analyzer.

Nitric acid is preconcentrated, apparently by reaction with cationic centers or by ligand substitution in the solid, polymeric WO_3 structure.

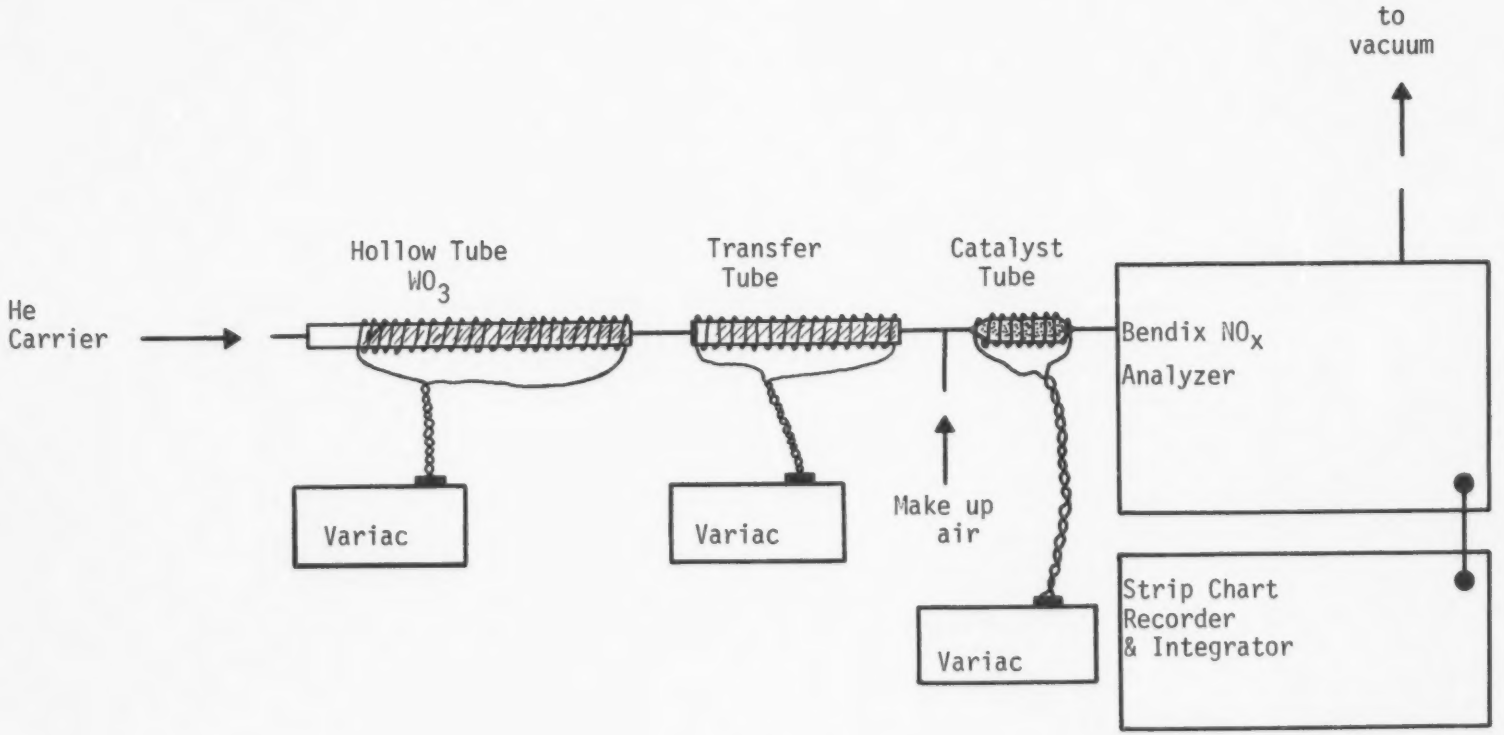


Figure 1. Apparatus Arrangement for Preconcentration Tube Analysis

Thus, the following reactions can account for the preconcentration of nitric acid:

$$NaHWO_4 \rightarrow H_2WO_6 + NaNO_3 \text{ (cationic centers)}$$

$$WO_2(OH)_2 + HNO_3 \rightarrow WO_2(OH)(NO_3) + H_2O \text{ (ligand substitution)}$$

The second reaction appears to be the more likely one. Nitric acid is removed from the preconcentration tube by heating during which nitrogen dioxide is formed. The mechanism for this is not yet definitely established but the following series of reactions are likely.

$$WO_2(OH)\,(NO_3) \xrightarrow[\text{over } 250°C]{\Delta} WO_3 + HNO_3$$

$$2WO_3 + 2HNO_3 \rightarrow 2NO_2 + H_2WO_4 + \tfrac{1}{2}O_2$$

$$H_2WO_4 \xrightarrow[100°C]{\Delta} WO_3 + H_2O$$

Heated tubes rehydrate immediately upon exposure to moist air to regenerate tungstic acid.

Tungstic acid and tungsten (VI) oxide are solids having high melting points but also having amphoteric acid-base character. The oxide has been coated in vacuum in a glassy form onto silica sand and on the interior of 6 mm o.d. quartz and Vycor(96-98% quartz) tubes. See Figure 2. Both of these types of materials have been used to preconcentrate ammonia and nitric acid from air. Tubes packed with tungstic acid on silica sand can be used to collect particulate ammonia (ammonium compounds) as well as particulate nitrates, such as metal nitrates. The combination of a hollow tube gas-preconcentration with a packed tube as shown in Figure 2 permits collection and analysis for gaseous and particulate NH_3 and HNO_3.

Preconcentration efficiency for hollow tubes depends upon tube length, flow rate, and the diffusion coefficient for the collected compound. For a

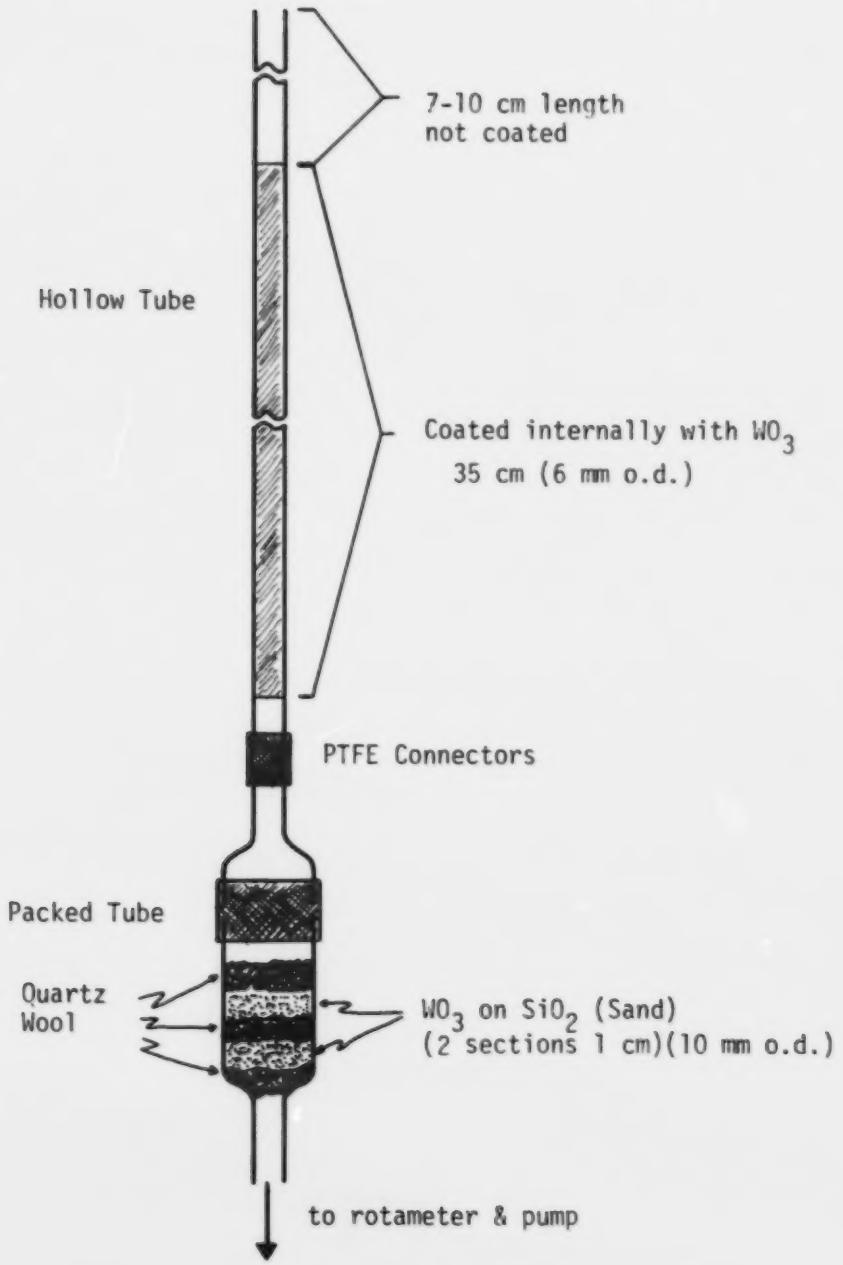


Figure 2. Sampling Arrangement for Hollow Tubes and Packed Tubes

35 cm. long tube and a flow rate of 1.0 L/min the collection efficiencies of NH_3 and HNO_3 (gaseous) are calculated from equation 1 (3) as follows:

$$(1\text{-}C/Co) = 0.819 \exp[-3.6568\pi \cdot D\frac{L}{F}] \quad (1)$$

NH_3: D = 0.236 (3) Efficiency = 99.7%

HNO_3: D = 0.15 (4) Efficiency = 97.8%

where (1-C/Co) is absorption efficiency, D is the diffusion coefficient, L is tube length and F is flow rate. These calculated efficiencies have been observed in other field tests. The validity of equation 1 in describing the preconcentration phenomenon has been studied in laboratory and other field tests (2).

Collection of total HNO_3 + NH_3, gaseous and particulate has been demonstrated experimentally using packed tubes (2). Leakage of approximately 5-6% is observed with tubes having 2 sections of tungsten oxide coated silica.

Analysis of preconcentrated components is accomplished by heating the tubes in an apparatus of the type shown in Figure 1. Detection of desorbed NH_3 is by means of a chemiluminescent NO_x analyzer preceded by a gold catalyst. The catalyst oxidizes NH_3 to NO. Nitric acid is desorbed from the preconcentration tubes as NO_2 and is converted to NO on the catalyst bed and is detected in the NO_x analyzer.

The transfer tube functions to separate NH_3 from HNO_3. Heating of the preconcentration tube removes preconcentrated NH_3 without conversion. Preconcentrated HNO_3 is converted to NO_2 which then passes through the cool transfer tube without being adsorbed. The NH_3 released is readsorbed onto the transfer tube. After NO_2 from nitric acid has been detected the transfer tube may be heated to desorb the NH_3. This process requires several minutes for each of the components as is shown in Figure 3, which is a typical

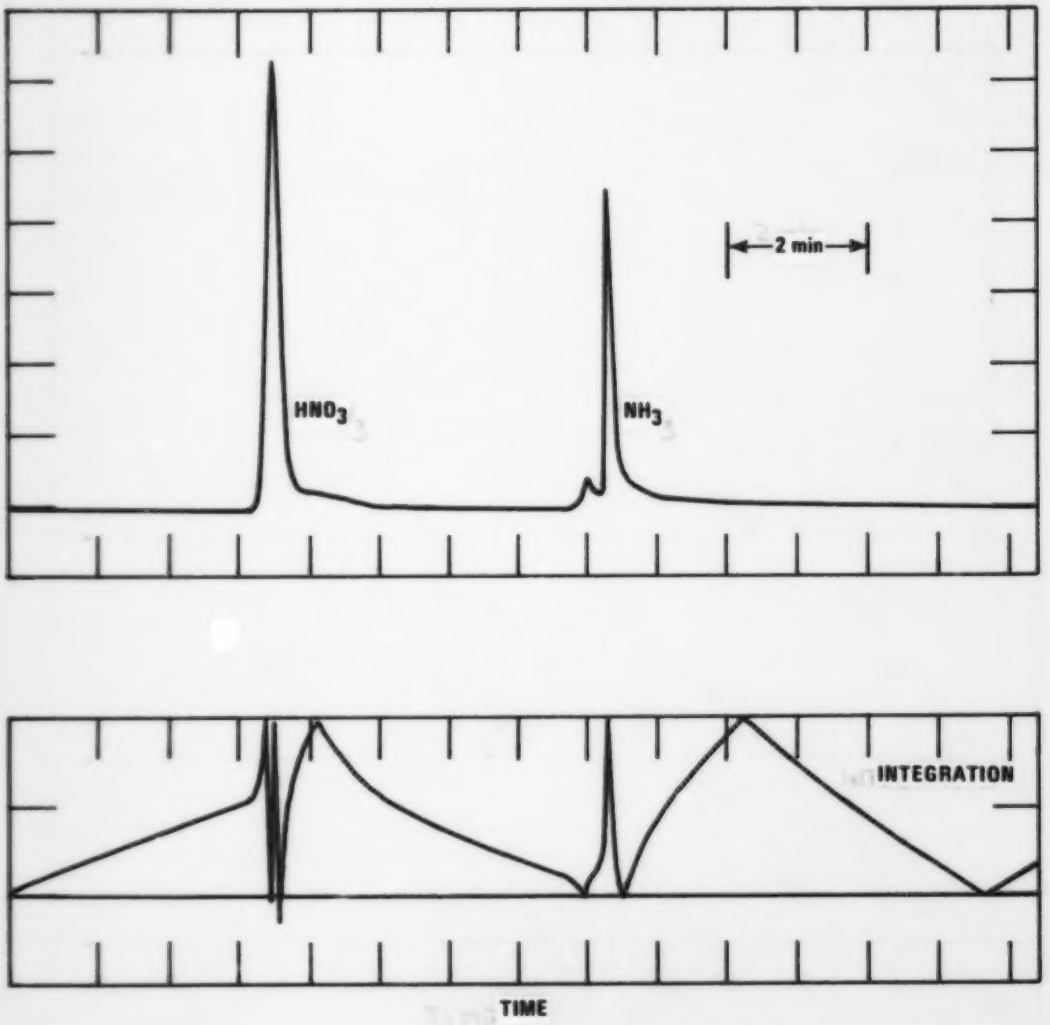


Figure 3. Typical Ambient Air Analysis for HNO_3 & NH_3

environmental analysis. Approximately 12 minutes is required in total for both analyses. A major problem is the time required for the peak "tail" to reach a constant signal level or to reach the original baseline. This is probably due to a solid-gas thermal desorption.

Detection limits of the method depend upon the compound sensed. Ammonia has a detection limit near 1 ng per sample while nitric acid has one near 4 ng per sample (as HNO_3). This permits analysis of low concentrations of both in air. For example, 1 ppb (vol.) of NH_3 in 30 liters is a 23 ng sample upon preconcentration and 1 ppb (vol.) HNO_3 in 30 liters is a 84 ng sample, both 20 times the detection limit.

The precision analysis results depends upon sample size. An estimate of this has been done in a replication experiment done on outdoor air sampled from a manifold. The average difference in duplicates for nitric acid was on the order of 5% relative for approximately 65 ng mean sample sizes (19 samples). This is somewhat poorer than is experienced with calibration curves using diffusion standards. With diffusion standards and a dynamic gas mixing system deviations of individual sample values from a calculated least squares fit line are usually in the 2-3% range.

Precision data for ambient ammonia monitoring gave an average difference of ± 8% for duplicates. This was, nevertheless, for comparatively small ammonia samples, approximately 6-10 ng (18 samples). Ammonia samples in the 20-30 ng range and calibration are more precise.

Interferences in the method have been investigated to some extent. Nitrogen dioxide does not interfere in that this gas does not absorb onto the tungstic acid surfaces in noteable amounts. Nitrogen dioxide does react with water to produce nitric acid and nitrous acid which can be oxidized to nitric acid in the presence of water. Ozone in large concentrations, above 300 ppb,

oxidizes adsorbed ammonia to a small extent. Selected common organic solvents are not adsorbed. Large pieces of organic matter accidentally impacted on the tube wall or collected on the packed tube decompose slowly and show an uneven increase in the background during analysis. This can be eliminated by careful handling of tubes and/or proper protection from gravity deposition of particles above approximately 5 microns in size.

Alaphatic amines interfere by appearing to give the same response as ammonia. Peroxyacetyl nitrate and similar PAN-like compounds may interfere by responding similarly to nitric acid. This has not been clearly established but is under investigation.

SECTION 4

FIELD DATA

Calibration curve data, data taken at ground level near Croton, Ohio and data taken from aircraft are presented in the following 13 tables. Also included, where available, are data on time of sampling, temperature, and dew point. Unless otherwise indicated results are in units of nanograms per liter, ng/L. This may be converted to ppb (vol.) values at standard temperature and pressure by using the multiplication factor 0.356 for nitric acid and 1.30 for ammonia.

The abbreviations in the column headings g, p and s are for gaseous, particulate and the sum respectively of ammonia or nitric acid. Ammonia and nitric acid in either the gaseous and particulate phase were calculated using the formula weights of NH_3 or HNO_3.

Calibration curve data in Tables 1 and 2 gave response in units of "strokes." This is a convenient area response unit when a Linear Instrument Co. integrating recorder is used. The least squares fit for the calibration curves was calculated assuming that ng standard weights were more accurate than response strokes. All analysis data given in subsequent Tables 3-13 were calculated using the calculated calibration curves given in Tables 1 and 2.

Instrument response to NH_3 was determined at the University of South Florida prior to the field work and at OSU Airport. The response was essentially the same. Response to nitric acid was determined prior to and immediately after the field work. The response was essentially the same.

Hollow tube and packed tube blanks for nitric acid were generally less than 1 ng. Hollow tube blanks for ammonia were not determined but are

known from prior experience to be on the order of 2-5 ng per tube. Packed tube ammonia blanks were generally low, 2-5 ng, over 16 hours in the laboratory but were substantially higher in aircraft use. Ammonia blanks were generally 5-10 ng. Blank values for ammonia were first substracted from total ammonia found on packed tubes prior to calculation of ng/L.

Ammonia leakage experiments were run to determine collection efficiency of hollow tubes. Data given in Table 11 indicate tubes were still of high efficiency near the end of the field sampling and analysis period. Data given in Table 12 indicate that packed tubes were likewise functioning properly for ammonia collection.

TABLE 1 Calibration Data: NH_3 and HNO_3 on Packed Tubes

NH_3 on Packed Tubes

Sample Size	Area Response
14.99 ng	2.40 strokes
29.97 ng	4.62 strokes
44.96 ng	7.28 strokes
59.94 ng	9.48 strokes

Response Curve

Slope = 0.159504,
Intercept = -0.031,
Corr. Coef. = 0.9993.

HNO_3 on Packed Tubes

Sample Size	Area Response
21 ng	0.55 strokes
42.5 ng	1.10 strokes
	1.25 strokes
84.5 ng	2.50 strokes
129.0 ng	3.95 strokes
171.0 ng	4.96 strokes
214.0 ng	6.18 strokes
257.0 ng	7.20 strokes
264.0 ng	7.40 strokes

Slope = 0.028118,
Intercept = 0.08,
Corr. Coef = 0.9988.

TABLE 2 Calibration Data: NH_3 and HNO_3 on Hollow Tubes

NH_3 on Hollow Tubes

Sample Size	Area Response
14.65 ng	2.93 strokes
43.95 ng	8.20 strokes
58.60 ng	10.54 strokes
73.24 ng	13.56 strokes

Response Curve

Slope = 0.17939,
Intercept = 0.27,
Corr. Coef = 0.9993

HNO_3 on Hollow Tubes

Sample Size	Area Response
20 ng	1.10 strokes
40.1 ng	1.76 strokes
80.3 ng	3.83 strokes
120.5 ng	5.30 strokes
123.2 ng	5.60 strokes
160.6 ng	7.25 strokes
165.0 ng	7.40 strokes
200.8 ng	8.70 strokes
246.4 ng	10.13 strokes

Slope = 0.040991,
Intercept = 0.38,
Corr. Coef = 0.9976

TABLE 3 Croton, Ohio Samples: August 6, 1980

Sampling Conditions

Event 1 Time = 1212-1227
Temperature = 28°C
Dew Point = 22.5°C

Event 2 Time = 1330-1345
Temperature = 28°C
Dew Point = 22.5°C

Event 3 Time = 1500-1515
Temperature = 27.3°C
Dew Point = 20.5°C

Event 4 Time = 1630-1645
Temperature = 29.2°C
Dew Point = 22.1°C

Data, ng/L

Event	Sample Time	Tube	Volume	$HNO_3(g)$	$HNO_3(p)$	$NH_3(g)$	$NH_3(p)$
1	1212-1227	V-5	16.35ℓ	9.03		0.83	
		#1	16.35ℓ		7.60		3.99
2	1330-1345	V-8	16.35ℓ	8.60		0.99	
		#2	16.35ℓ		6.32		6.10
3	1500-1515	V-9	16.35ℓ	10.74		0.76	
		#3	16.35ℓ		6.30		4.05
4	1630-1645	V-10	16.35ℓ	11.30		1.18	
		#4	16.35ℓ		6.26		3.30

TABLE 4 Croton, Ohio Samples: August 8, 1980

Sampling Conditions

Event 1
Time = 1210-1225
Temperature = 29.9°C
Dew Point = 25.3°C
Wind Speed = 4.5 m/s
Wind Dir. = 239°
Rel. Humidity = 77%

Event 2
Time = 1252-1307
Temperature = 31.4°C
Dew Point = ——
Rel. Humidity = 71%
Wind Speed = 5.7 m/s
Wind Dir. = 268°

Event 3
Time = 1336-1353
Temperature = 31.9°C
Dew Point = 24.2°C
Rel. Humidity = 64%
Wind Speed = 3.4 m/s
Wind Dir. = 242°

Event 4
Time = 1412-1427
Temperature = 31.7°C
Rel. Humidity = 66%
Wind Speed = 3.6 m/s
Wind Dir. = 254°

Event 5
Time - 1454-1509
Temperature = 31.7°C
Rel. Humidity = 65%
Wind Speed = 6.5 m/s
Wind Dir. = 240°

Event 6
Time = 1533-1548
Temperature = 31.7°C
Rel. Humidity = 67%
Wind Speed = 6.8 m/s
Wind Dir. = 228°

Data, ng/L

Event	Sample Time	Tube	Volume	$HNO_3(s)$	$NH_3(s)$
1	1210-1225	#1	16.35ℓ	12.46	5.62
2	1252-1307	#2	16.90ℓ	8.95	6.53
3	1336-1353	#3	18.53ℓ	8.20	4.89
4	1412-1427	#4	16.35ℓ	7.90	4.22
5	1454-1509	#5	16.35ℓ	5.47	4.03
6	1533-1548	#7	16.62ℓ	7.77	4.99
7	1100-2200	#6	0	0.00	22.8ng

TABLE 5 Aircraft Samples, Chem 1: August 8, 1980*

Event	Sample Time	Tube	Volume	$HNO_3(g)$	$HNO_3(p)$	$HNO_3(s)$	$NH_3(g)$	$NH_3(p)$	$NH_3(s)$
4	1105-1107 1218-1238	V-10	23.71ℓ	22.90			1.88		
		#9	23.71ℓ		43.72			3.23	
16	1350-1405	V-5	15.6 ℓ	27.6			3.34		
		#22	15.6 ℓ		24.95			9.59	
21	1711-1724	V-8	13.52ℓ	31.41			3.49		
		#23	13.52ℓ		18.18			3.00	
27	1908-1924	#8	16.93ℓ			31.03			5.10
31	2010-2025	V-9	15.6ℓ	23.6			4.11		
		#10	15.6ℓ		17.47			4.32	
Blank	1000-2400	#13	0			0			10.03ng

*Data, ng/L

TABLE 6 Croton, Ohio Samples: August 9, 1980

Event 1 Time = 1401-1416
Temperature = 30.1°C
Rel. Humidity = 64%
Wind Speed = 3.3 m/s
Wind Dir. = 256°

Event 2 Time = 1437-1453
Temperature = 27.5°C
Rel. Humidity = 49.5%
Wind Speed = 1.6 m/s
Wind Dir. = 281°
Thunderstorm began at end of sample.

Event 3 Thunderstorm just ended.
Time = 1600-1615
Temperature = 23.4°C
Rel. Humidity = 98.1%
Wind Speed = 2.2 m/s
Wind Dir. = 235°

Event 4 Time = 1643-1658
Temperature = 24.0°C
Rel. Humidity = 90.2%
Wind Speed = 2.2 m/s
Wind Dir. = 259°

Data, ng/L

Event	Sample Time	Tube	Volume	$HNO_3(g)$	$HNO_3(p)$	$NH_3(g)$	$NH_3(p)$
1	1401-1416	V-5	16.35ℓ	1.51		1.49	
		#10	16.35ℓ		4.37		1.79
2	1437-1453	V-9	17.44ℓ	5.16		1.58	
		#9	17.44ℓ		6.33		3.32
3	1600-1615	V-10	16.35ℓ	1.51		1.49	
		#23	16.35ℓ		2.94		2.31
4	1643-1658	V-8	16.35ℓ	8.59		0.78	
		#22	16.35ℓ		5.08		3.60

TABLE 7 Aircraft Samples, Chem 1: August 9, 1980*

Event	Sample Time	Tube	Volume	HNO_3(s)	NH_3(s)
2	1139-1149	#7	10.40ℓ	18.32	12.03
3	1228-1238	#5	10.40ℓ	3.83	6.51
4	1319-1329	#1	10.40ℓ	Lost	Lost
7	1738-1754	#4	16.64ℓ	46.87	5.58
7	1816-1828	#6	12.48ℓ	20.02	3.81
8	1912-1925	#15	13.52ℓ	20.40	6.03
9	2023-2033	#8	10.40ℓ	15.32	10.22
Blank	1100-1000	#2	0	0	12.35ng
Blank	1100-1000	#4	0	0	12.35ng

*Data, ng/L

TABLE 8 Aircraft Samples, Chem 1: August 11, 1980*

Event	Sample Time	Tube	Volume	$HNO_3(g)$	$HNO_3(p)$	$HNO_3(s)$	$NH_3(g)$	$NH_3(p)$	$NH_3(s)$
	1310-1321	#6	10.95ℓ			30.7			10.48
	1434-1449	V-8	16.35ℓ	11.52			3.92		
		#5	16.35ℓ		3.46			2.57	
	1939-1943	#15	4.09ℓ			16.0			9.84
	1945-1957	#17	13.0ℓ			14.5			4.48
	2003-2013	#8	10.40ℓ			1.25			4.62
	2040-2041	#14	1.59ℓ			25.6			10.6
	2317-2327	#4	10.54ℓ			5.03			1.90
Blank	1200-1200	#9	0			16.2ng			7.8ng
Blank	1200-1200	#12	0			0			10.5ng
Blank	1200-1200	#13	0			6.2ng			5.8ng
Blank	1200-1200	#16	0			0			10.3ng

*Data, ng/L

TABLE 9 Aircraft Samples, Chem 1: August 12, 1980*

Event	Sample Time	Tube	Volume	HNO_3(g)	HNO_3(p)	NH_3(g)	NH_3(p)
1	1459-1509	V-9	10.40ℓ	4.53		1.67	
		#4	10.40ℓ		3.49		2.84
2	1510-1520	V-8	10.40ℓ	5.28		3.88	
		#5	10.40ℓ		2.54		1.84
5	1610-1622	V-7	12.48ℓ	5.75		1.51	
		#22	12.48ℓ		4.30		3.20
7	1627-1637	V-10	10.40ℓ	4.74		1.72	
		#14	10.40ℓ		0.87		0.83
10	1721-1734	V-1	13.52ℓ	4.76		1.38	
		#15	13.52ℓ		2.00		1.68
11	1747-1757	V-5	10.40ℓ	6.78		2.05	
		#23	10.40ℓ		4.74		3.06

*Data, ng/L

TABLE 10 Aircraft Samples, Chem 1: August 13, 1980*

Event	Sample Time	Tube	Volume	$HNO_3(g)$	$HNO_3(p)$	$HNO_3(s)$	$NH_3(g)$	$NH_3(p)$	$NH_3(s)$
	1254-1304	#2	10.43ℓ			5.49			3.40
	1324-1334	#17	10.40ℓ			0.10			0.13
	1408-1418	V-1	10.40ℓ	3.38			1.87		
		#1	10.40ℓ		7.65			4.58	
	1423-1433	#14	10.40ℓ			6.29			5.38
	1445-1455	V-9	10.40ℓ	6.29			5.38		
		#9	10.40ℓ		4.55			2.52	
	1505-1515	V-7	10.58ℓ	2.44			1.93		
		#7	10.58ℓ		2.86			1.43	
	1533-1543	V-8	10.47ℓ	9.13			1.14		
		#8	10.47ℓ		6.86			4.60	
	1551-1600	#4	8.77ℓ			6.81			2.17
	1627-1637	#22	10.3ℓ			4.49			2.05
	1638-1648	V-10	10.68ℓ	9.39			6.00		
		#10	10.68ℓ		6.95			2.32	
Blank	1000-2400	#16	0			0			4.6ng
Blank	1000-2400	#23	0			0			7.4ng
Blank	1000-2400	#13	0			0			7.8ng
Blank	1000-2400	#6	0			0			12.1ng
Blank	1000-2400	#12	0			0			4.4ng

*Data, ng/L

TABLE 11 Ammonia Leakage Experiments: August 14, 1980

Tubes	Sample(ng)	Response(ng)	Leakage%*
V-10	59.96	57.88	2.8
#10		1.7	
V-5	44.97	45.23	7.1
#5		3.19	
V-8	59.96	61.0	8.6
#8		5.20	
V-9	44.97	45.39	5.7
#9		2.57	
V-1	59.96	60.67	2.2
#1		1.31	

*Leakage is defined as ng of NH_3 passing through a hollow tube and collected in a packed tube.

TABLE 12 Quality Check: August 14, 1980

Tubes	Sample(ng)	Response(ng)*	Difference (%)
#7	59.96	62.3	+3.9
#4	59.96	58.07	-3.1
#8	44.97	47.41	+5.4
#5	59.96	57.26	-4.5
#10	59.96	60.27	+0.5
#1	44.97	45.97	+2.2
#9	59.96	56.95	-5.0

*Used calibration curve, TABLE 1, NH_3 on packed tubes.

TABLE 13 Aircraft Samples, Chem 1: August 15, 1980*

Event	Sample Time	Tube	Volume	$HNO_3(g)$	$HNO_3(p)$	$HNO_3(s)$	$NH_3(g)$	$NH_3(p)$	$NH_3(s)$
1	1329-1344	#23	15.60ℓ			Lost			Lost
4	1353-1403	#15	10.40ℓ			2.64			1.82
5	1404-1414	V-1	10.40ℓ	2.37			2.82		
		#1	10.40ℓ		7.24			4.36	
6	1415-1432	V-7	17.68ℓ	2.47			1.25		
		#7	17.68ℓ		4.92			1.31	
	1433-1440	#22	7.28ℓ			5.48			3.24
	1442-1453	#2	11.44ℓ			4.51			3.25
	1454-1504	#4	10.40ℓ			6.22			3.77
	1511-1521	#17	10.40ℓ			8.12			1.99
	1529-1541	#14	12.48ℓ			4.13			1.00
	1545-1555	V-8	10.40ℓ	5.35			4.22		
		#8	10.40ℓ		4.89			1.77	
	1635-1645	V-10	10.40ℓ	4.15			2.80		
		#10	10.40ℓ		5.50			1.80	
	1649-1659	V-9	10.40ℓ	3.42			2.96		
		#9	10.40ℓ		Lost			Lost	
	1701-1711	V-5	10.40ℓ	1.76			3.03		
		#5	10.40ℓ		3.87			2.09	
	1714-1721	#16	7.28ℓ			3.90			2.43
Blank	1000-2400	#6	0			0			7.9ng
Blank	1000-2400	#12	0			0			8.9ng
Blank	1000-2400	#13	0			0			4.1ng

*Data, ng/L

REFERENCES

1. R.K. Stevens, T.G. Dzubag, R.W. Shaw, Jr., W.A. McClenny, C.W. Lewis and W.E. Wilson, Characterization of the Aerosol in the Great Smoky Mountains, Environmental Science and Technology, 1980, submitted.

2. R.S. Braman and Timothy J. Shelley, Preconcentration and Analysis of Ammonia and Amines in Air., Quarterly Report - August, 1979, E.P.A. Grant No. R806688010, Research Triangle Park, N.C.

3. M. Ferm, Atmospheric Environment, 13, 1385-1393 (1979).

4. Estimated from: E.R. Gilliland, Industrial and Engineering Chemistry, 26, 681-685 (1934).